

Advanced Accelerator Group

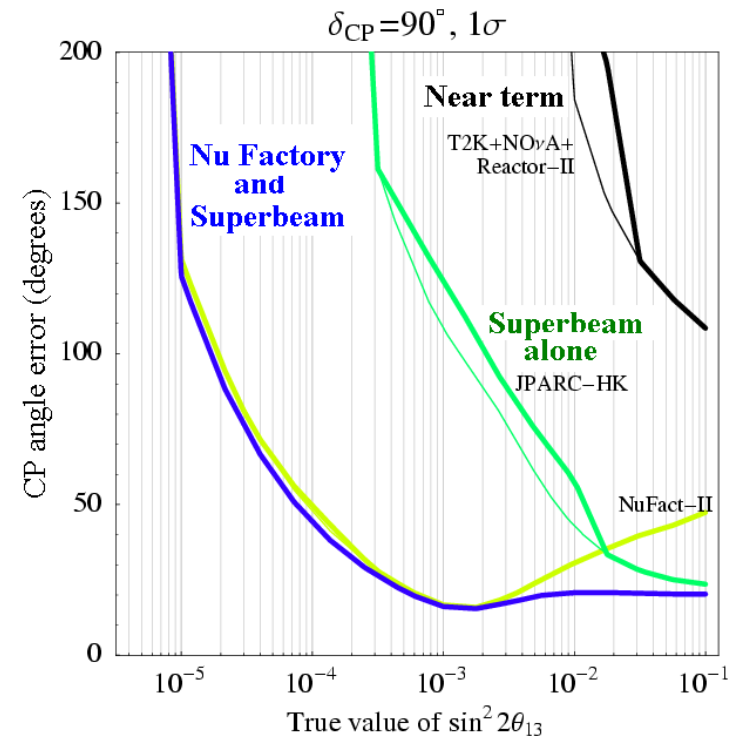
R B Palmer 4/18/06

Activities

- With Neutrino Factory & Muon Collider collaboration (NFMCC):
 - Neutrino Factory Design and Simulation
 - Muon Collider Design and Simulation
 - Completed MuScat Experiment
 - Mercury Jet target Simulation with CC Dept
 - Liquid Target Experiment MERIT with Instrumentation
- Non NFMCC Advanced Accelerator work
 - Solid Target Radiation Studies
with NE Dept (Energy Science & Tech)
 - Fixed Field alternating Gradient (FFAG) Studies
with CAD (Collider Accelerator Dept)

1) Neutrino Factory Studies

- Lower Backgrounds than Conventional Beams
- Only way to study lepton CP Violation if θ_{13} small



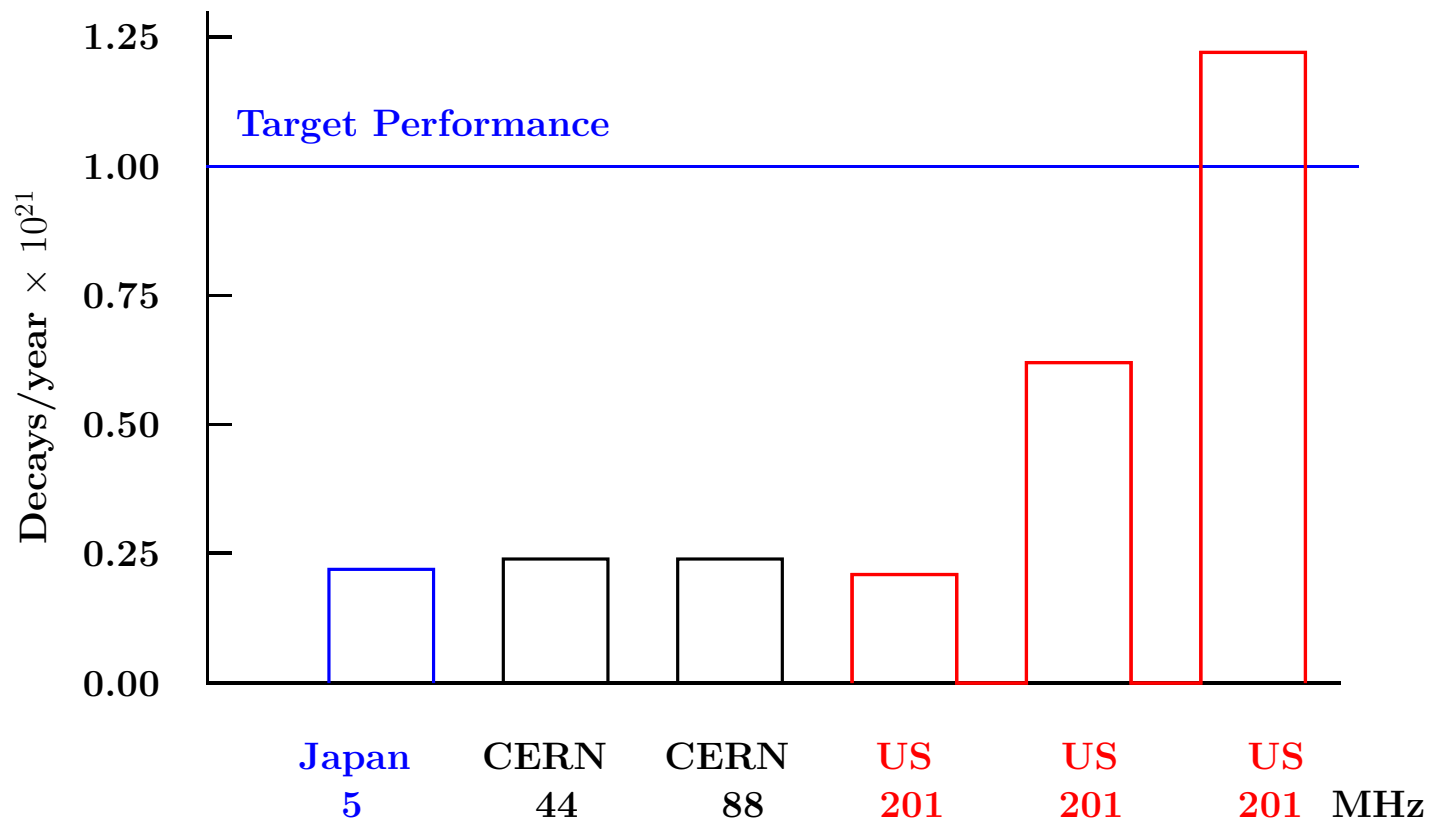
Errors in CP angle δ

BNL Effort:

- Palmer is one of two Spokespersons for NFMCC
- Group is leading NFMCC Design and Simulation effort
- Working on 12 month International Scoping Study (ISS)
Ending August 06 **UK, CERN, US, Japan**
Aiming to settle on a single concept for further study

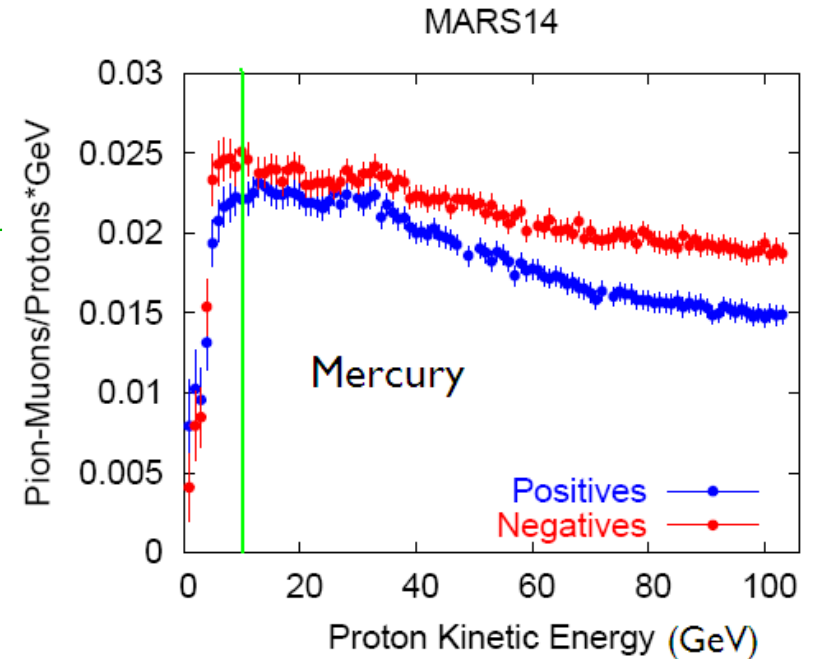
ISS Progress

- Comparison of schemes using different rf frequencies
 - Only 201 MHz Study 2A achieves 10^{21} mu decays per year goal
 - Capture into multibunches gives large longitudinal acceptance
 - System captures both signs
 - Higher gradients reduce decay loss
 - Even higher frequencies would reduce trans acceptance



ISS Progress Continued

- Studies of best proton energy
 - Mercury favors 8-10 GeV **NEW**
 - Carbon favors 5 GeV,
But C is 15% worse than Hg
& space charge problems at 5 GeV



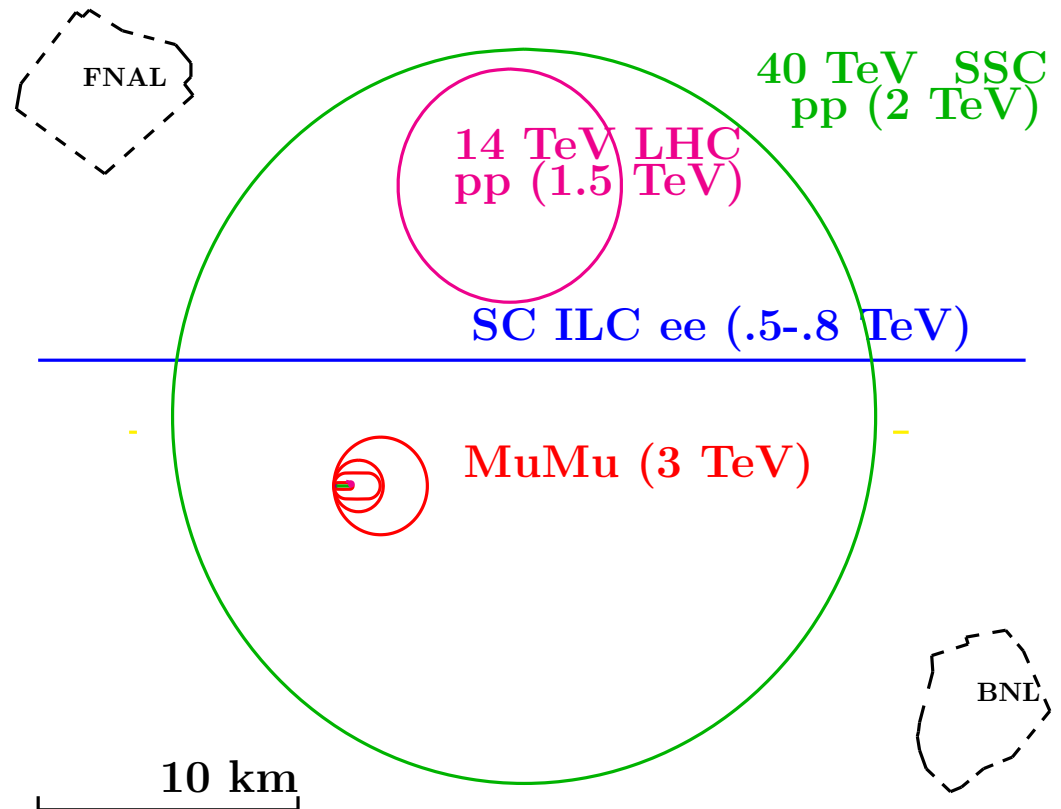
- Studies of proton space charge and rf loading
 - Favors 5 bunch proton train ($0.5 \mu\text{s}$ separation)
to reduce loading and space charge problems **NEW**
- Studies of tolerances and effects of rf failures or lower gradients
 - Relatively small performance losses

2) Muon Collider Studies

- Muons are point like
- Same physics as e^+e^- , plus some
- But 40,000 less radiation
- So Muon Colliders circular and much smaller than linear

BNL Effort:

- Collider parameters
4 and 8 TeV Designs
- Required Cooling Design
Substantial recent progress



New Collider Parameters for 4 and 8 TeV c of m

	Initial	Later	
C of m Energy	4	8	TeV
Luminosity	5	20	$10^{34} \text{ cm}^2\text{sec}^{-1}$
Tune Shift	0.09	0.09	
Ring <bending field>	5.18	10.36	T
Long Emittance	72	72	pi mm rad
Trans Emittance	25	25	pi mm mrad
Beta at intersection	3	1.5	mm
Beam sigma at IP	2.8	1.4	μm
Repetition Rate	8	4	Hz
Muon Beam Power	10	10	MW
Depth for ν rad	180	670	m
Proton Driver power	$\approx 2.4^*$	$\approx 1.2^*$	MW

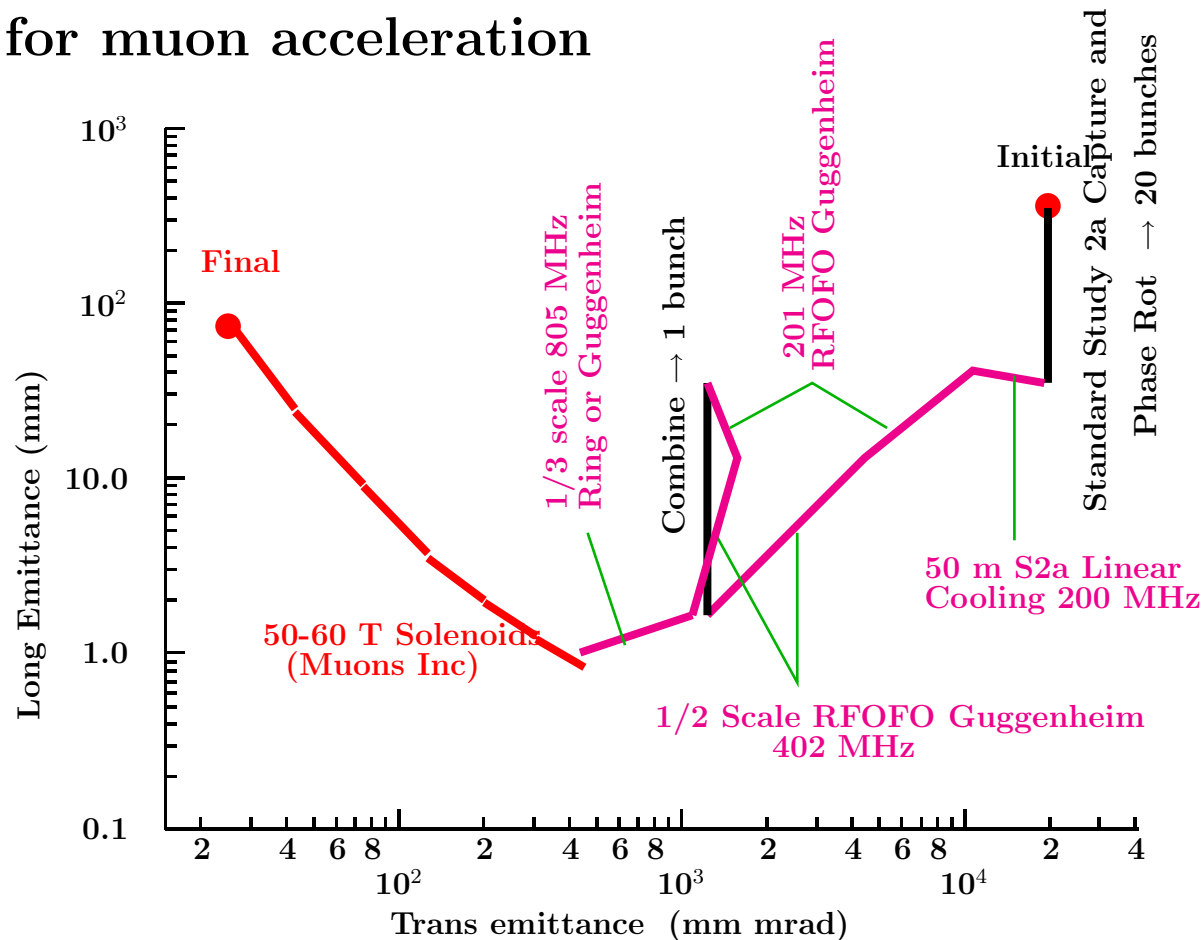
* Dependent on losses in cooling and acceleration

- Same cooling system requirements for the two designs
- Initial ring design is from Snowmass 96 Study
- Later design has more challenging $\langle B \rangle$, β and depth

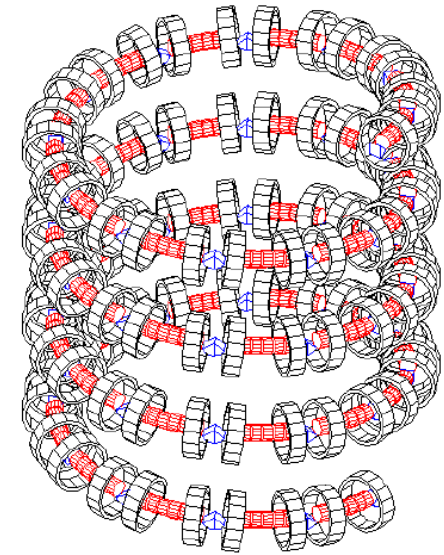
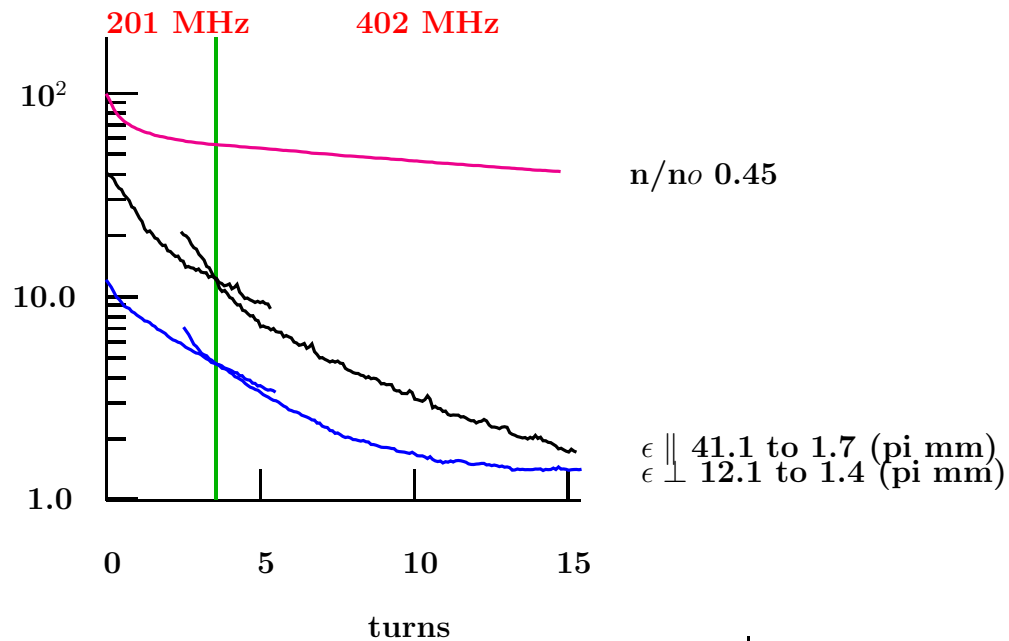
Complete Cooling Scenario NEW

All sections simulated at some level

- Neutrino Factory type front end including initial cooling
- 6 D cooling in "Guggenheim" channels
- Muon bunch merging
- 50-60 T small bore HTS solenoids (with Muons inc.)
- ILC linacs for muon acceleration

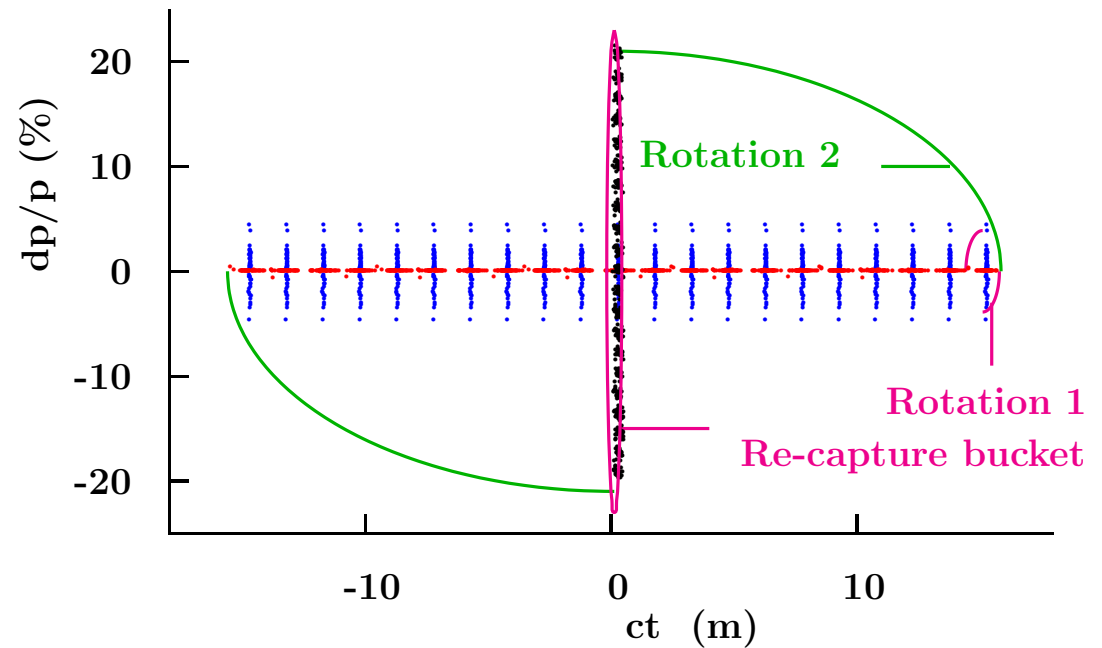


6 D Cooling in "Guggenheim" helices

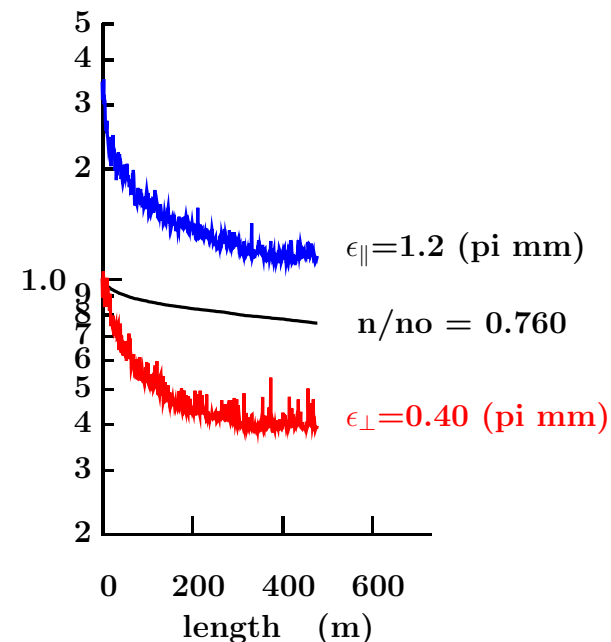
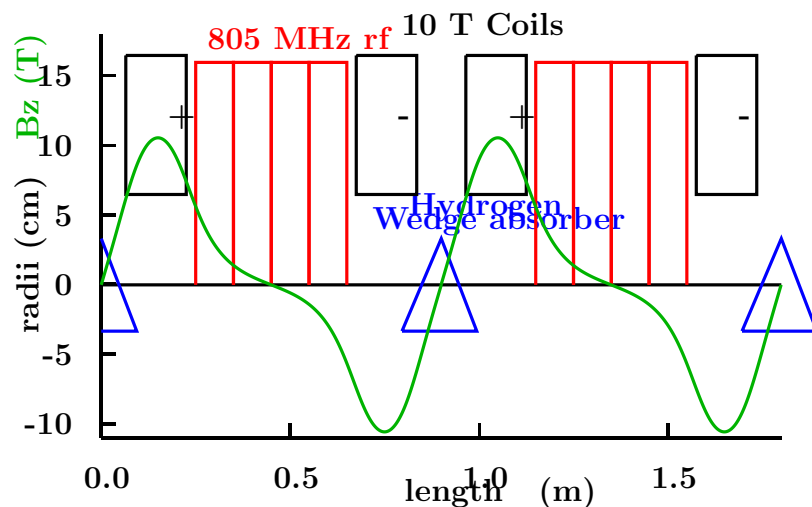


Bunch Merging

- Drifts in wigglers
- #1 Rotation 201 MHz
- #2 Rotation 5 MHz

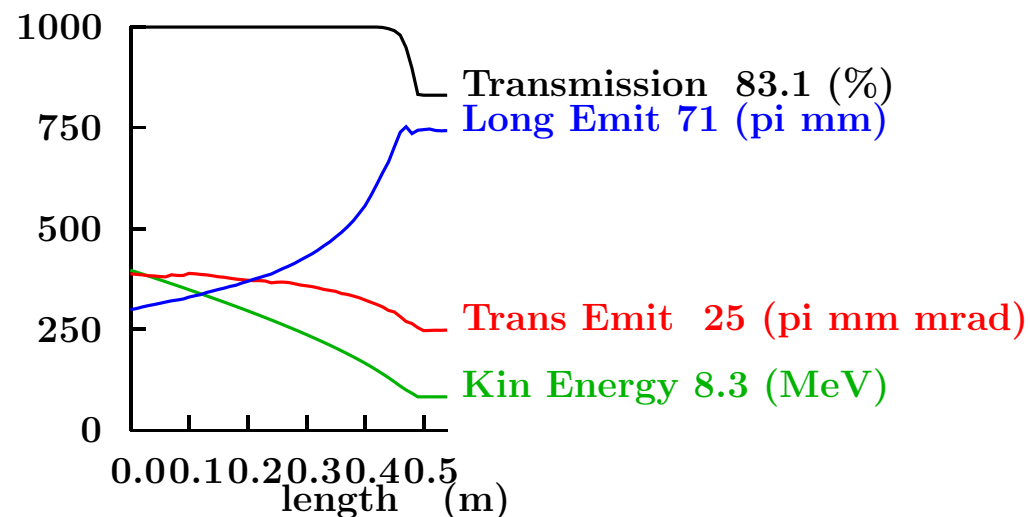
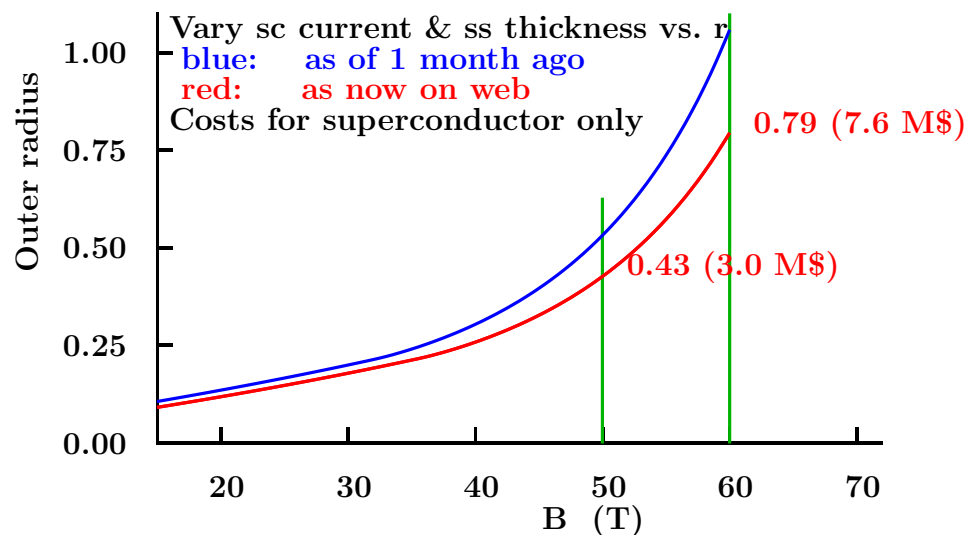


New low beta 805 MHz RFOFO Ring



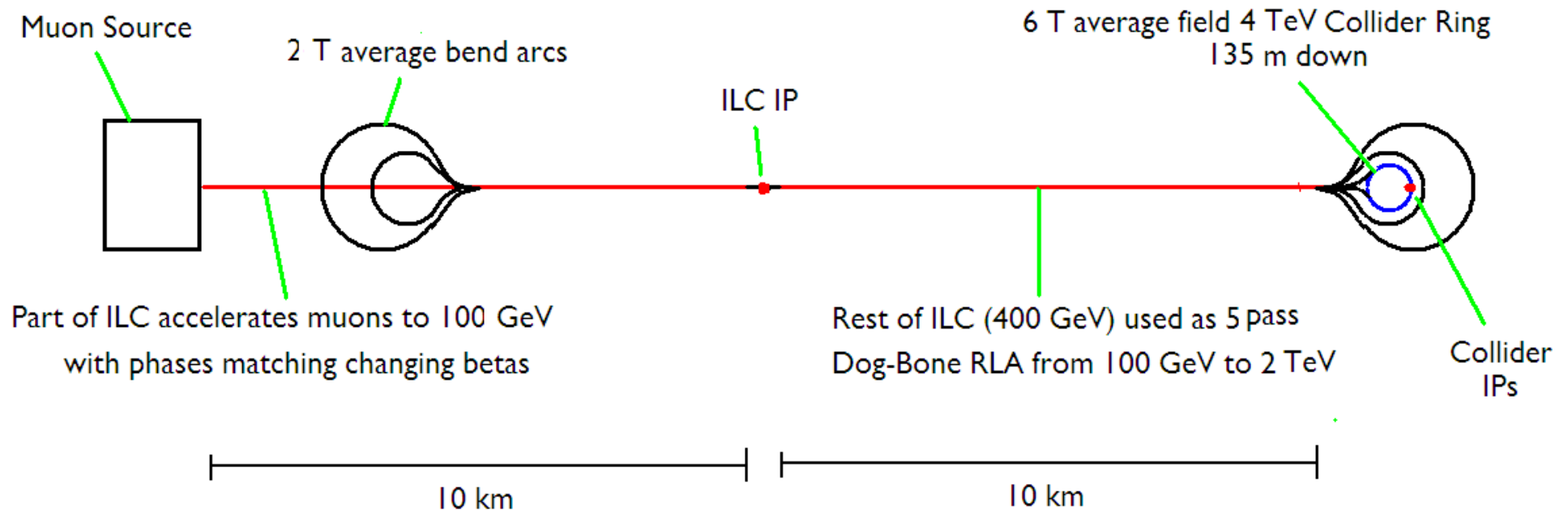
Final Cooling in HTS 50-60 T solenoids

Layer wound, based on American Superconductor BSCCO Specs



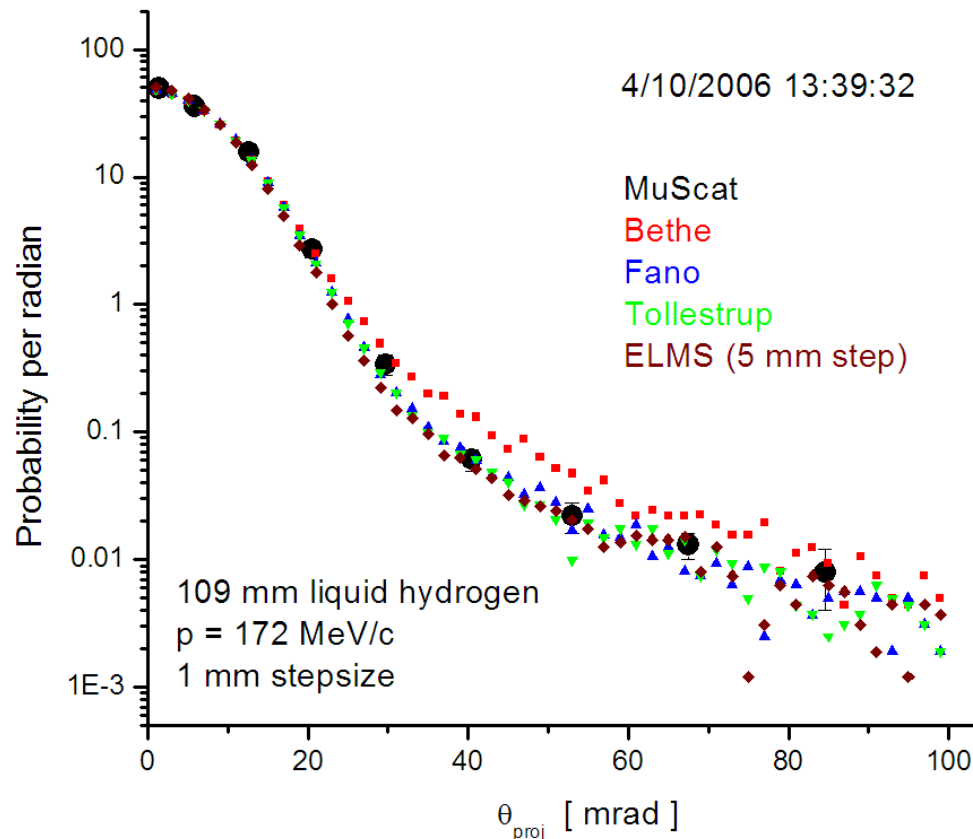
Acceleration using ILC ?

- If ILC constructed, it is ideal Muon Accelerator
- Potential ILC "upgrade"



3) Completed MuScat experiment

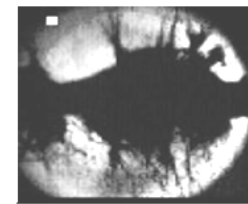
Comparison of experiment results and scattering calculations



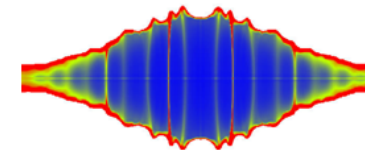
- Bethe Method (as used previously in ICOOL) overestimates scattering on light atoms
- ELMS, Fano, and Tollestrup give good agreement
- Use of ELMS, Fano, or Tollestrup (all now in ICOOL) gives small gains Neutrino Factory, but significant gains for collider

4) Jet target Simulation

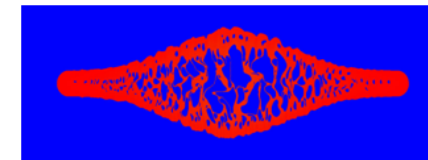
Samulyak (CC Computational science)



Observed



Homogeneous model



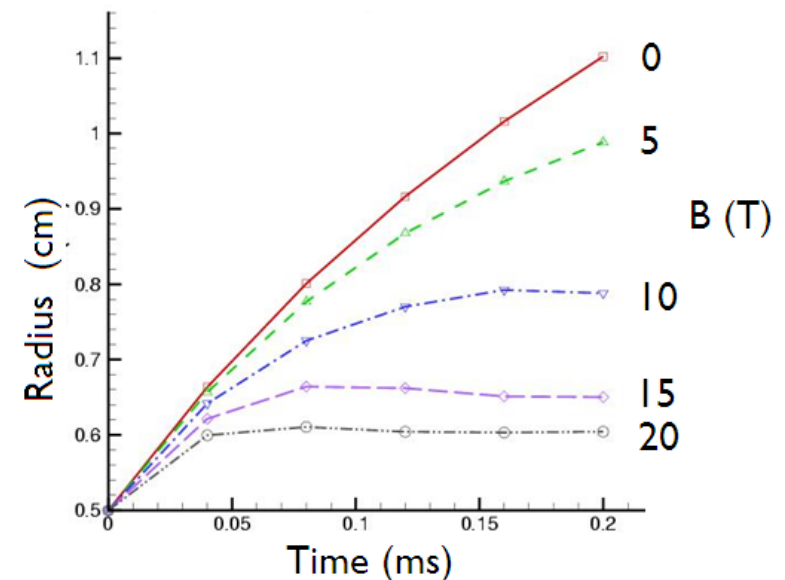
Heterogeneous model

- Good simulation of blow up using two codes

- Good simulation of jet distortion in field using several codes

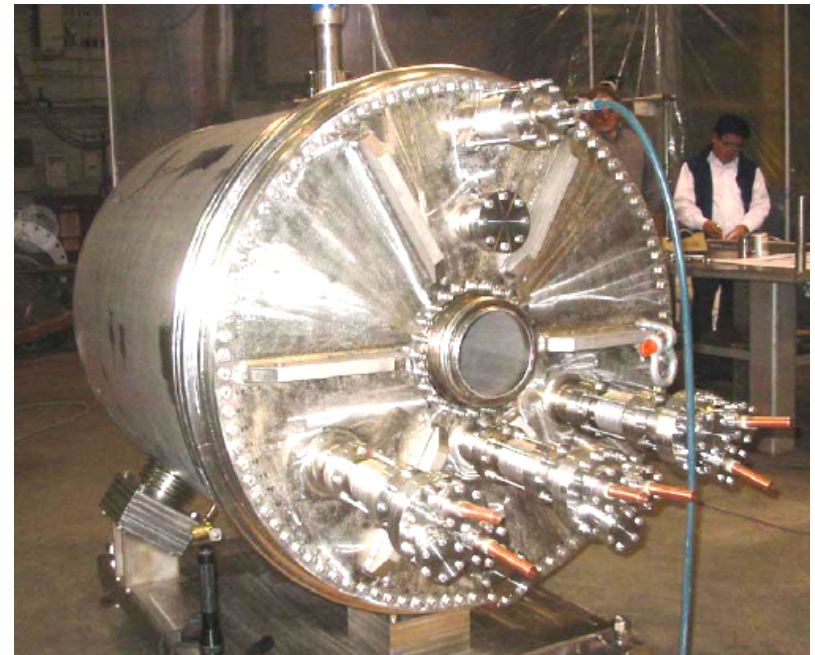
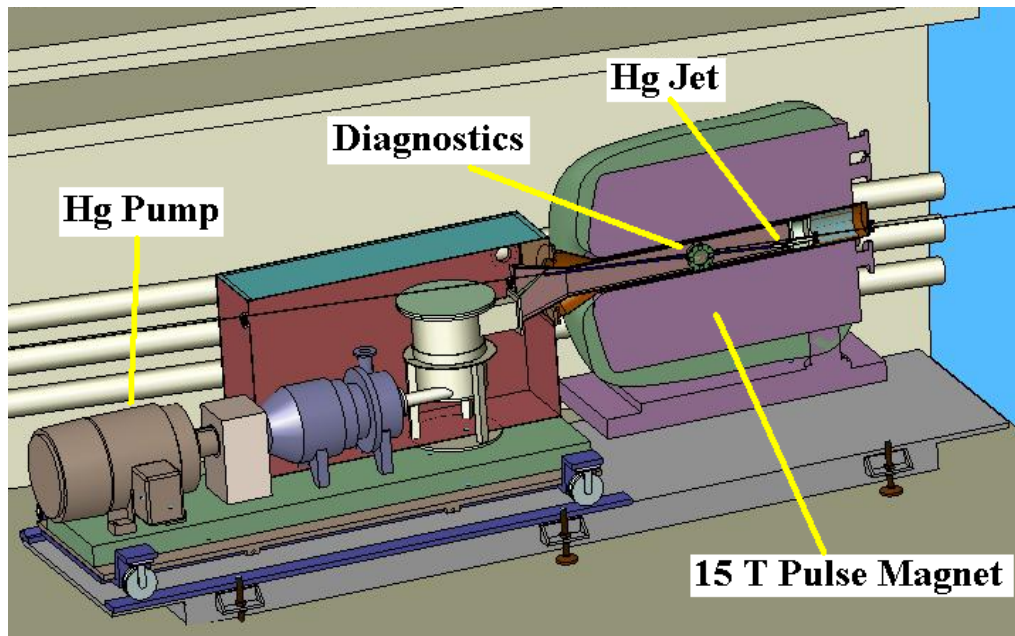
- Starting study of blow up in field with one model

Strong suppression of blowup, but conductivity of multiphase is complicated



5) Liquid Target Experiment MERIT

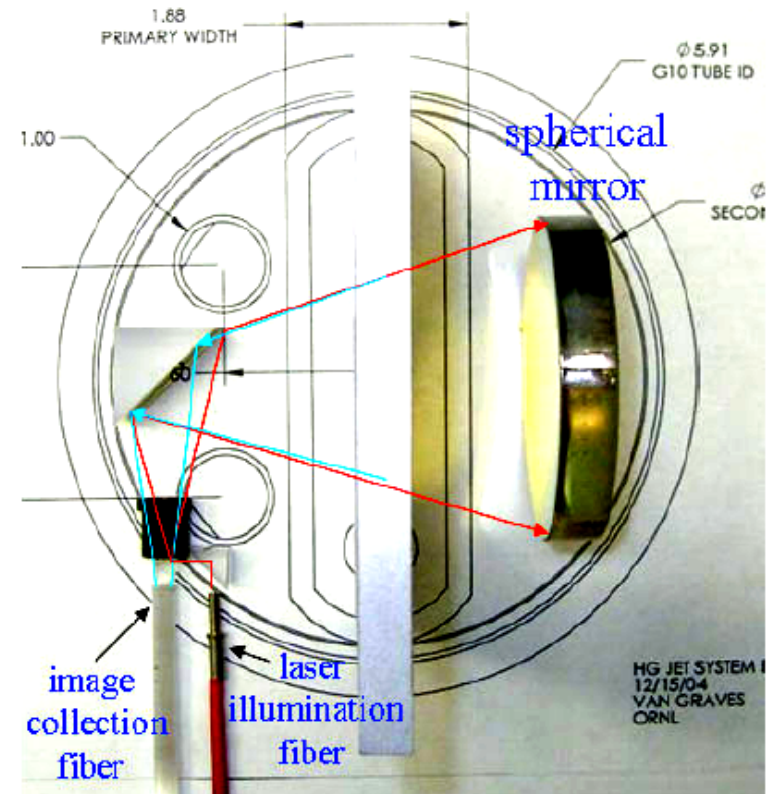
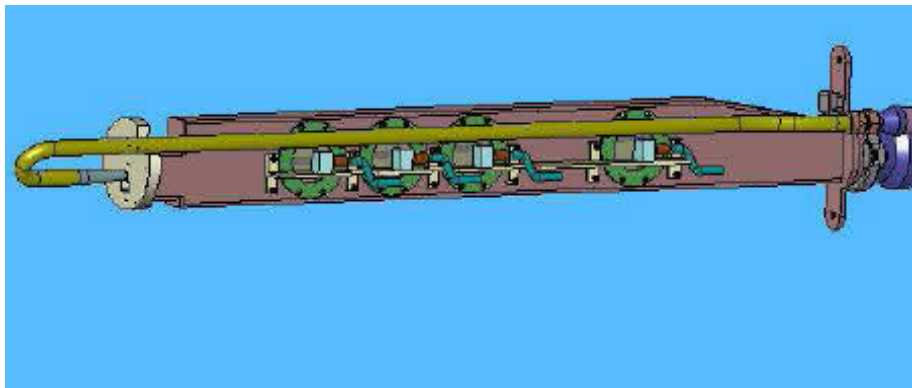
- BNL, MIT, CERN, RAL, Princeton, Oak Ridge Collaboration
- Harold Kirk is one of two Spokespersons
- Will expose mercury Jet to CERN proton beam
- Probably only practical target at 4 MW
- BNL oversight of 15 T pulsed magnet acquisition
Magnet now tested to 15 T at MIT
- Instrumentation Department building Optics system to observe mercury dispersion by beam



Optical Diagnostics

Designed in BNL Instrumentation Division (T. Tsang)

- 4 view ports
- Retrodirector illumination, optical fiber image transport



- Radiation tests of windows and fiber optics
- Fused silica components selected and ordered
- Radiation tests of small lens elements underway

Components

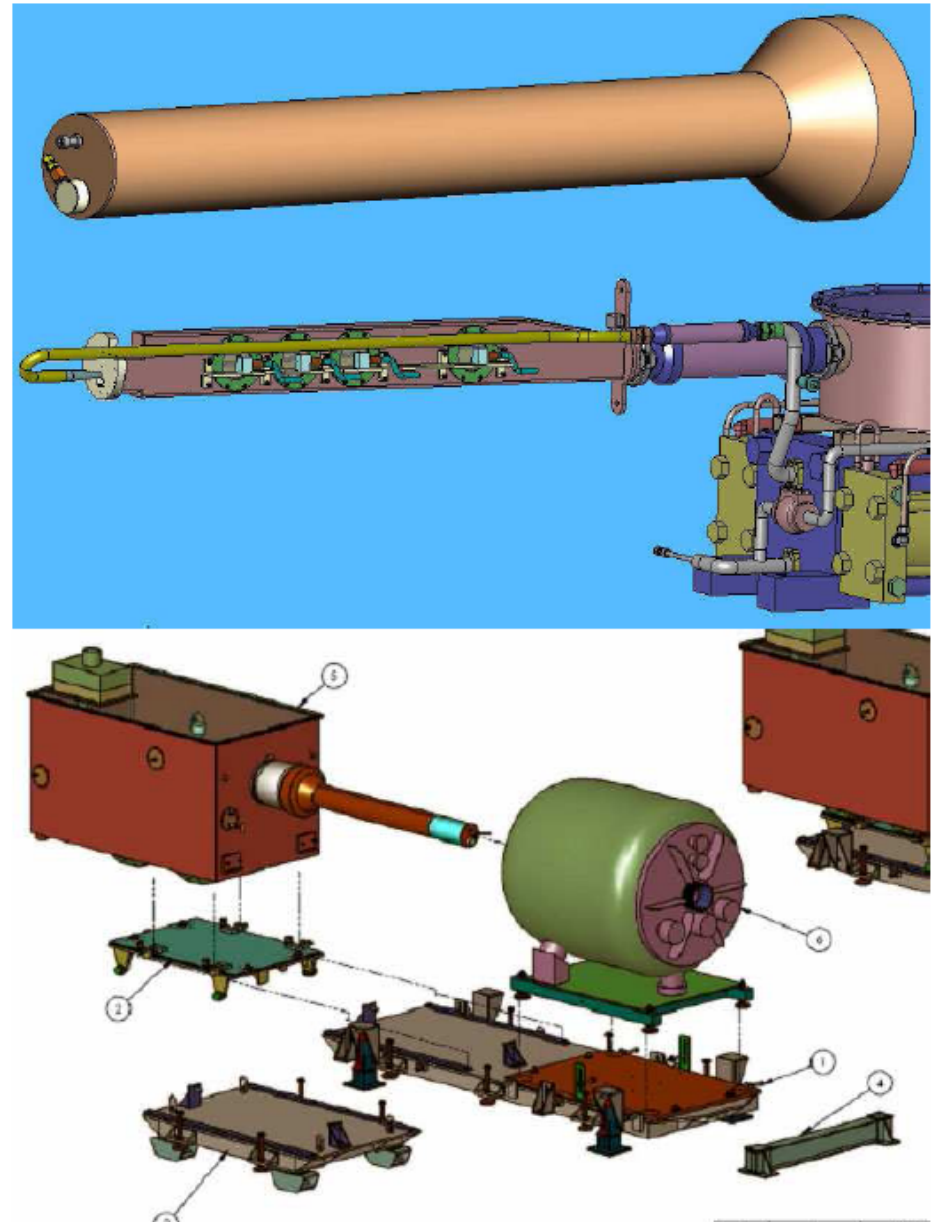
The secondary containment “snout” and the associated primary containment vessel will be built from titanium if affordable.

High preliminary bids may require us to revert to stainless steel + titanium windows. Issue then is brazing of Ti to SS.

Goal: Complete fabrication by 1 June.

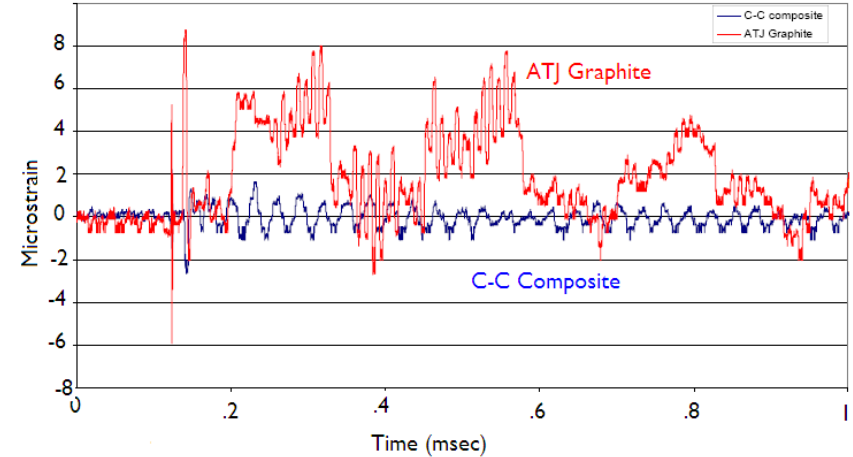
Stainless-steel secondary containment box now being fabricated at Princeton U. Completion \approx 1 May.

Baseplates now being fabricated at U. Miss. Completion \approx 1 May.

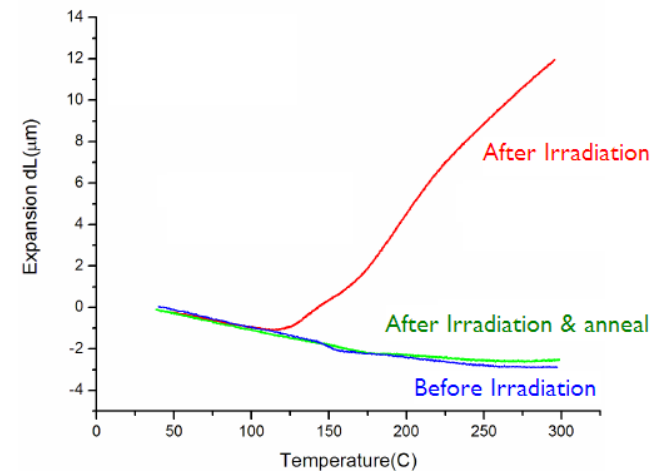


6) Solid target Studies (Non NFMCC)

- Target Shocks in AGS Beam
- Study effect of radiation on strength & thermal expansion
- Many Materials
Vascomax, AlBe, C-C Composite, Invar, Ni/Al, Ti alloy, Gum metal
- Will see equipment on tour
- In 2004 study
 - For both C-C Composite & Invar
 - Low Temp Coef. reduces shocks
 - Radiation spoils low coef.
- In 2005 study
 - Annealing restores low coefficient in both materials
 - will it work for larger exposures?



Shock for Graphite & C-C



Thermal expansion of C-C:
before, after rad, after anneal

Future plans

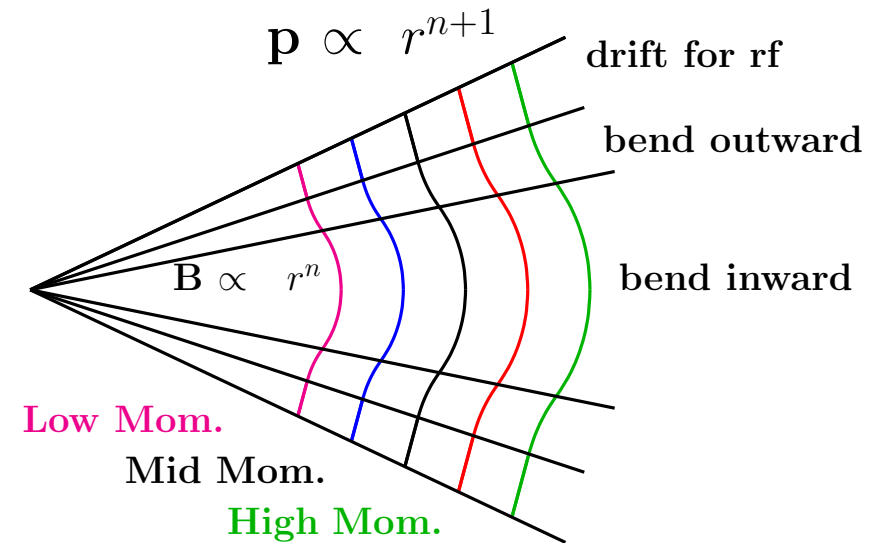
- Add new materials
- Study thermal conductivities vs. radiation
- Run longer BLIP Radiation Exposure
 ≈ 1 Disp vs. 0.2 Disp in previous exposure
- Use 350 k\$ of 400 k\$ from Neutrino Initiative
 - Support NE Dept work
 - Fund BLIP Radiation Exposure
 - Buy thermal conductivities equipment

7) FFAG (Fixed Field alternating Gradient) Acc. (Non NFMCC)

Accept momenta over factor of 2-3

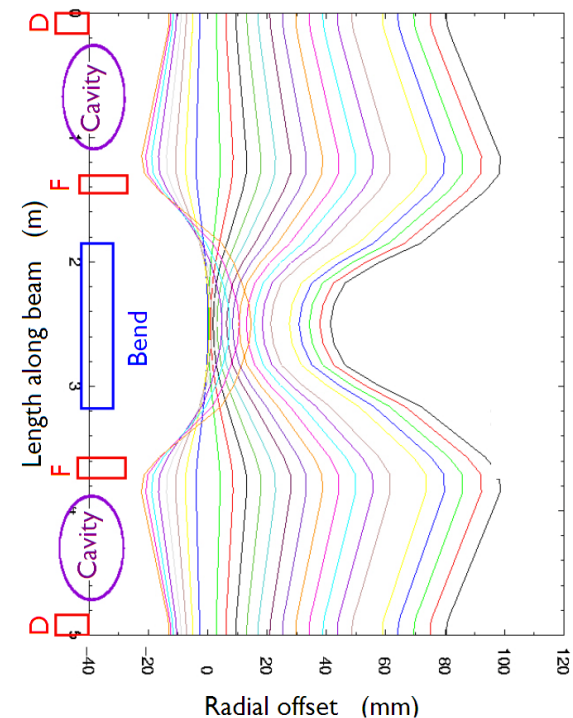
a) Scaling Designs (MURA)

- Tune independent of momentum
- But large magnet apertures
- Several operating examples in Japan



b) Non-Scaling (Carol Johnstone)

- Orbits are not similar, but closer
→ Smaller apertures
- But tunes not constant
- Electron model proposed in UK



Applications

Medical, Waste Disposal, Muon Acc
Proton Booster, AGS Doubler

Japan involved in Medical, Waste Disposal & Muon Acc

BNL involved in Design Studies of Muon Acc, Proton Booster
& Doubler

BNL work this year

- Study suggests much higher costs of scaling vs. non-scaling FFAG
Apertures and fields are larger and rf must have low frequency
- Study of recently discovered amplitude dependent problem in non-scaling designs
Requires re-optimizations
will result in some cost increase
- Studies of G. Rees' isochronous non-linear non-scaling FFAG
Possible instability at high energy end
- Detailed design of proposed Electron Model

- **Budget**

FY	03	04	05	06	07	08
Muon Ops	1054k	1056k	970k	900k	995k	1020k
Non-Muon Ops	250k	250k	250k	250k	277k	295k
Muon Equip.	300k	0	100k	0	0	0
Total	1604k	1306k	1320k	1150k	1272k	1315k
Diff. %		-19	+1	-13	+11	+3
DO	333k	240k	180k	198k	204k?	210k?
MC Equip.	300	265	578	405	?	?
FTE	7.3	6.7	6.2	5.2	5.2	5.2

- Lost one physicist in 05. Manpower for MERIT is now weak
- 06 MST insufficient for required travel and normal expenses,
- Temporary relief by 0.2 FTE working for NSLS
- 07 looks ok

Conclusion

- Progress on ISS Study
Simulations achieve goal performance
- Progress on Muon Collider Design
First partial simulation of complete scenario

- Results from MuScat experiment
Deviations from Bethe established
- Progress on Mercury Target Simulation
Predictions on field effect
- Progress on MERIT Target Experiment
15 T magnet tested

- New Result on Solid Targets
Low expansion restored in two materials
- Progress on FFAG Studies
Discovery and understanding of amplitude effect

Appendix: MERIT Budget

	Tech. Board Sept. 21 2004	MERIT Review Dec. 12 2005	Spending Profile by FY		
			FY05	FY06	FY07
Magnet Systems					
Fabrication	0	60	60	0	0
Testing	200	200	48	112	40
Cryogenics	550	385	0	250	135
Power Supply	390	210	0	160	50
Hg Jet					
Systems integration	200	200	85	75	40
Nozzle development	50	65	25	40	0
Optics components	25	100	16	74	10
Fabrication	40	170	0	170	0
Shipping	0	20	0	14	6
Operations	218	263	19	65	179
Decommisioning	60	60	0	0	60
Simulations	150	150	40	50	60
Material R&D	75	75	30	0	45
3 Year Project Cost	1958	1958			
Spending Profile			323	1010	625
Funding Profile			693	640	625